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ORIGINAL CONTRIBUTION

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Studies on the Ozyorsk population: dosimetry

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Background and aims of the study

The Mayak Production Association (MPA) is located in the northern part of Chelyabinsk Oblast, and its operating areas are about 10 km from the town of Ozyorsk. Ozyorsk is the largest populated area nearby, but other nearby populated areas include Novogorny Village, New Metlino Village, and Kyshtym Town.

The long-term objective of this (unfunded) project is reconstruction of the time-dependent individual radiation doses to residents of the City of Ozyorsk and the surrounding area from atmospheric releases of radionuclides from the facilities of the Mayak Production Association (MPA). The time period to be included is from 1948 to the present.

This information would be of use for several epidemiologic studies of the regional population. Two pilot-scale studies of thyroid disease among residents of Ozyorsk have found an increase in the prevalence of thyroid nodules among exposed persons compared to unexposed persons [1] and an increased incidence of thyroid carcinoma in Ozyorsk residents [2]. The success of follow-on studies would depend upon the availability of thyroid doses to be provided by this proposed project. The availability of credible thyroid doses would allow the quantification of risk of thyroid disease and the evaluation of factors such as host susceptibility, age and time effects, and gender differences. Perhaps more importantly, studies of the Ozyorsk residents would not be encumbered with the complications associated with previous early detection screening, as in the Chernobyl studies, or previous medical conditions, as in the ^{131}I medical studies.

In addition, the releases to the atmosphere from the MPA stacks provide a source of exposure to other populations that are the subject of epidemiologic investigation; these populations include the Extended Techa River Cohort (JCCRER Direction 1), the MPA workers (JCCRER Direction 2), and proposed studies of the East Urals Radioactive Trace (EURT) cohort. The doses received by these cohorts from the atmospheric releases at the MPA represent a confounding variable that cannot be considered without the information to be provided by this proposed project.

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Atmospheric discharges

The operation of the MPA began during the cold war period and caused multiple environmental and public health problems. The startup of the enterprise and production increases in the first decade of operation were performed under a sense of urgency and without appropriate scientific knowledge and technological experience in the field of ecology. This resulted in the release of several important radionuclides through a variety of pathways. For this study the pathway of importance is the routine discharge of radionuclides into the atmosphere during the early years. The most significant radionuclide for this pathway is believed to be ^{131}I.

Current estimates of the yearly releases of ^{131}I into the atmosphere (through 60–150 m high stacks) are shown in Fig. 1. The discharge rate depended on the production capacity and efficiency of gas-cleaning systems. The maximum discharge rate occurred during the early

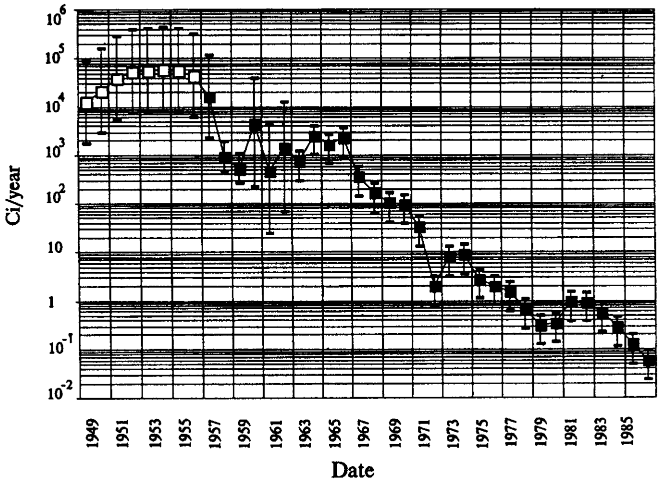

Fig. 1 Releases of ^{131}I to the atmosphere for 1949–1986 (Solid points are based upon measurements, hollow points are based upon reconstructions)

operations, when the gas-cleaning systems were rigged only with the most simple filter installations, and also in the 1950s and 1960s because the production capacity increased through the construction and operation of new plants.

Environmental contamination was monitored almost from the very beginning of MPA operation, but direct, regular monitoring of total beta activity discharged from the Plant B stack was begun only in June 1957. Plant DB, which was an analogue of Plant B, was put into operation in September 1959. Monitoring of radioactive discharges into the atmosphere from Plant DB were recorded from the very beginning. Discharges of both gross beta activity and of ^{131}I were monitored, and monitoring of other radionuclide discharges was started later. The monitoring procedure was the same as at Plant B.

The total release of ^{131}I estimated on the basis of Fig. 1 is 15,000 TBq (400,000 Ci). This is roughly half of the release estimated from the Hanford facility [3] in the U.S.

Meteorological information

An important consideration of the exposure of the Ozyorsk and other populations is the concentration of ^{131}I in surface air, and the determination of meteorological conditions around the MPA site is of fundamental importance. Provided the release rate is known, the concentration of ^{131}I in surface air can be estimated with Gaussian plume or other types of models on the basis of the following information: annual wind rose (fraction of time for each wind direction), wind velocity, frequency of occurrence of atmospheric stability categories, air temperature, and precipitation.

Investigation of the meteorological parameters has been performed in accordance with requirements for dose calculations. Results from direct observations at the weather station Argayash are available for this purpose. Argayash is a flat forest-steppe station, and is typical for the surrounding locale; the observational data are considered to be representative for the conditions within a radius of 50–70 km of the MPA.

Contamination of pasture and foods

Once the air concentration at a given location is known it is rather simple to estimate the contamination of pasture, the intake of ^{131}I by cows, and the secretion of ^{131}I into milk. The contamination of other aboveground food crops can also be estimated.

Food consumption in Ozyorsk

Consumption of contaminated food is the main source of internal exposure for the population. For this reason reconstruction of the sources of food and of the amounts of food types that are consumed is an important part of the retrospective assessment of population exposure. Some preliminary work on this topic has already been accomplished. For example, according to information in the MPA archives, milk supplies were received from the following four farms: ONIS farm, Burino sovkhoz (a type of collective farm), Kuluyevo sovkhoz, and farms of the Argayash region.

According to information from the Gossanepidnadzor (Bureau of Sanitary Epidemiology) there was a herd of private cattle in Ozyorsk up to 1957, and milk from this herd was consumed locally. A small part of the milk consumed in Ozyorsk was made from dry concentrate.

Sales of milk in Ozyorsk increased during the course of time; this corresponds to the change in population from 50,000 persons in the beginning years to 90,000 persons at the present time. Further analysis of the milk supply over a long time period has shown that the main sources of milk were the farms at Burino and Kuluyevo, but the details of supply have changed with time. For example, the contribution of the milk from the Burino farm has decreased from 65.3% in 1957 to 14.4% in 1991. The contribution of Argayash farms increased greatly over the same time from 4.6% in1959 to 54.2% in 1991. The fractional supply of milk from the ONIS and Kuluyevo farms has not changed significantly during this time period. The same can be said about the milk contribution produced from dry concentrate.

Dose assessment

The radiation effect on the population caused by radionuclide discharges in the atmosphere can be traced to a distance of 60–70 km from the MPA, including the Ozyorsk population. The exposure consists of external exposure (due to the radioactive cloud and gamma-emitting nuclides that accumulated on the ground surface) as well as internal dose (due to the intake of radionuclides into the body by inhalation from the cloud and by consumption of agricultural products manufactured in the region subjected to radioactive fallout from atmospheric discharges).

Data to support a dose reconstruction are available in the Mayak archives, and some of this information has been discussed above. The bulk of the radioactive materials in the early atmospheric releases has decayed to undetectable levels at the present time (e.g., ^{131}I, $^{103/106}$Ru). A small amount of information concerning ^{131}I in milk around the MPA is available for a brief period in the 1960s. Detailed information on the environmental behavior of iodine was collected in the 1980s, based on measurements of ^{129}I. A large amount of information is available from routine monitoring in Ozyorsk in the 1950s; however, this consists largely of gross-beta measurements of air, snow, soil, and vegetation at a limited number of locations.

It is evident that monitoring of the ^{131}I releases began during the period of sharp reduction of the releases, as a result of the installation of protective measures. Levels of release during the unmonitored period were reconstructed by Drozhko and Khokhryakov [4] and by Khokhryakov and Drozhko [5] by assuming that the majority of the iodine entered the atmosphere during the dissolution of irradiated fuel. The magnitude of the release was estimated from the reactor-power output, the retention time of the fuel prior to dissolution, the type of dissolving technology, and the presence of off-gas scrubbing equipment and the effectiveness of its operation. The larger contributions to the combined dose during this period were made by the radioactive noble gases (^{41}Ar, ^{85m}Kr, ^{97}Kr, ^{88}Kr, ^{133}Xe, ^{135}Xe, ^{138}Xe) and ^{131}I, primarily due to operation of the industrial graphite-uranium reactors and the radiochemical plant. In the 1950s the maximum exposure rate from gamma emitters in the discharged cloud at the Ozyorsk location was 400–600 μR h^{-1}. At the same time, some discharge-monitoring results showed the discharge rate of ^{131}I to be as high as 400 GBq h^{-1} (10 Ci h^{-1}). In comparison with the noble gases and ^{131}I, the radiation effect from other radionuclides in the discharges is estimated to have been minor.

Measurements of Pu-body burdens

As part of a study of Pu exposure in workers, measurements have also been reported by Hohryakov[1] et al. [6] for tissues collected in 1990–1991 from the autopsies of 60 adult members of the general population in Ozyorsk. The results were an average body burden of 3.75±1.45 Bq for 35 persons of long-term residence. This compared with 0.11±0.07 Bq for five persons from Ufa, a background location in the Urals. These body burdens are estimated to correspond to an effective dose at time of death of approximately 50 μSv.

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[1] A peculiar spelling of the name Khokhryakov.